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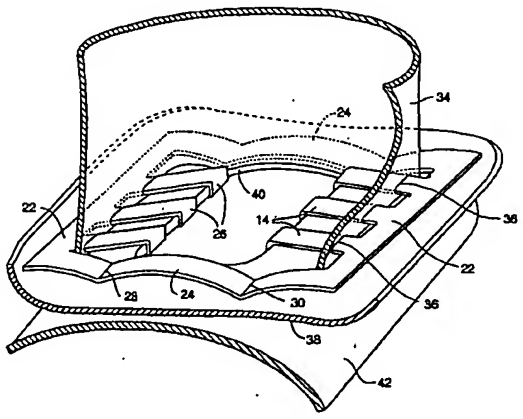
(54) Title: SUTURELESS CLOSURE FOR CONNECTING A BYPASS GRAFT TO A TARGET VESSEL



(57) Abstract: The anastomosis device according to the present invention is a one piece device for connecting a graft vessel to a target vessel without the use of conventional sutures. The anastomosis device includes a frame for receiving and holding the end of a graft vessel in an everted position and first and second spreading members configured to be inserted into an opening in the target vessel. The first and second spreading members are arranged substantially in a plane for insertion into an opening in a target vessel, and are moved away from one another to capture the edges of the opening in the target vessel securing the graft vessel to the target vessel. One version of the anastomosis device includes a plurality of linkages arranged in two rows for grasping opposite sides of an opening in the target vessel. A portion of the linkages fold outward to trap vessel walls on opposite sides of the opening in the target vessel. The anastomosis devices greatly increases the speed with which anastomosis can be performed over known suturing methods.

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SUTURELESS CLOSURE FOR CONNECTING A BYPASS GRAFT TO A TARGET VESSEL

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to an anastomosis device and method, and more particularly, the invention relates to an anastomosis device for forming a sutureless connection between a bypass graft and a blood vessel.

Brief Description of the Related Art

Vascular anastomosis is a procedure by which two blood vessels within a patient are surgically joined together. Vascular anastomosis is performed during treatment of a variety of conditions including coronary artery disease, diseases of the great and peripheral vessels, organ transplantation, and trauma. In coronary artery disease (CAD) an occlusion or stenosis in a coronary artery interferes with blood flow to the heart muscle. Treatment of CAD involves the grafting of a vessel in the form of a prosthesis or harvested artery or vein to reroute blood flow around the occlusion and restore adequate blood flow to the heart muscle. This treatment is known as coronary artery bypass grafting (CABG).

In the conventional CABG, a large incision is made in the chest and the sternum is sawed in half to allow access to the heart. In addition, a heart lung machine is used to circulate the patient's blood so that the heart can be stopped and the anastomosis can be performed. In order to minimize the trauma to the patient induced by conventional CABG, less invasive techniques have been developed in which the surgery is performed through small incisions in the patient's chest with the aid of visualizing scopes. Less invasive CABG can be performed on a beating or stopped heart and thus may avoid the need for cardiopulmonary bypass.

In both conventional and less invasive CABG procedures, the surgeon has to suture one end of the graft vessel to the coronary artery and the other end of the graft vessel to a blood supplying vein or artery. The suturing process is a time

consuming and difficult procedure requiring a high level of surgical skill. In order to perform the suturing of the graft to the coronary artery and the blood supplying artery the surgeon must have relatively unobstructed access to the anastomosis site within the patient. In the less invasive surgical approaches, some of the major coronary arteries cannot be easily reached by the surgeon because of their location. This makes suturing either difficult or impossible for some coronary artery sites. In addition, some target vessels, such as heavily calcified coronary vessels, vessels having very small diameter, and previously bypassed vessels may make the suturing process difficult or impossible.

An additional problem with CABG is the formation of thrombi and atherosclerotic lesions at and around the grafted artery, which can result in the reoccurrence of ischemia. The thrombi and atherosclerotic lesions may be caused by the configuration of the sutured anastomosis site. For example, an abrupt edge at the anastomosis site may cause more calcification than a more gradual transition.

Accordingly, it would be desirable to provide a sutureless vascular anastomosis device which easily connects a graft to a target vessel. It would also be desirable to provide a sutureless anastomosis device which is formed of one piece and is secured to the target vessel in a single step.

SUMMARY OF THE INVENTION

The present invention relates to an anastomosis device for connecting of a graft vessel to a target vessel. The device includes at least two spreading members being substantially in a plane in an undeployed state. The spreading members move out of the plane to support an opening in a target vessel in a deployed state.

In accordance with an additional aspect of the present invention, an anastomosis device for connecting a graft vessel to a target vessel includes a frame for receiving and holding a graft vessel, and first and second spreading

members configured to be inserted into a target vessel. At least one of the spreading members is movably connected to the frame and allows movement of the spreading members with respect to each other. The frame is deformable and deformation of the frame moves the spreading members.

According to a further aspect of the invention, an anastomosis device for connecting a graft vessel to a target vessel includes a frame for receiving and holding a graft vessel, and first and second spreading members configured to be inserted into a target vessel. At least one of the spreading members is movably connected to the frame and allows movement of the spreading members with respect to each other. Features are provided on the spreading members for moving the spreading members with respect to the frame.

In accordance with another aspect of the invention, an anastomosis device for connecting a graft vessel to a target vessel includes a frame for receiving and holding a graft vessel, and first and second spreading members configured to be inserted into a target vessel. At least one of the spreading members is movably connected to the frame allows movement of the spreading members with respect to each other. The frame includes features for deforming the frame to move the spreading members.

In accordance with another aspect of the invention, an anastomosis device for connecting a graft vessel to a target vessel includes a plurality of linkages arranged in two rows for grasping opposite sides of an opening in the target vessel. Each of the plurality of linkages include a plurality of angled struts surrounding a bendable central strut. Two end members are connected to opposite ends of the two rows which when moved away from one another expand the linkages and cause the bendable central struts to bend, folding a portion of the linkages outward to trap vessel walls on opposite sides of the opening in the target vessel.

In accordance with another aspect of the present invention, a method of performing anastomosis includes the steps of providing a one-piece anastomosis device, everting an end of a graft vessel around a first portion of the anastomosis device, inserting a second portion of the anastomosis device into an opening in a side wall of a target vessel, and pivoting the first portion with respect to the second portion to capture edges of the opening in the target vessel with the anastomosis device such that a fluid passage is established between the graft and the target vessel.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in greater detail with reference to the preferred embodiments illustrated in the accompanying drawings, in which like elements bear like reference numerals, and wherein:

FIG. 1 is a perspective view of a first embodiment of an anastomosis device in a configuration prior to use;

FIG. 2 is a top view of a preformed blank for forming the anastomosis device of FIG. 1;

FIG. 3 is a perspective view of the anastomosis device of FIG. 1 with a partially cut away graft vessel wrapped around the device and the device fingers inserted into an opening in the target vessel;

FIG. 4 is a perspective view of the anastomosis device of FIG. 1 with the fingers spread to secure the graft vessel to the target vessel;

FIG. 5 is a perspective view of an alternative embodiment of an anastomosis device prior to use;

FIG. 6 is a top view of a preformed blank from which the anastomosis device of FIG. 5 is formed;

FIG. 7 is a perspective view of the anastomosis device of FIG. 5 with the a partially cut away graft vessel wrapped around the device and the device being inserted into an opening in the target vessel;

FIG. 8 is a perspective view of the anastomosis device of FIG. 5 securing a graft vessel to a target vessel;

FIG. 9 is a perspective view of another alternative embodiment of an anastomosis device prior to use;

FIG. 10 is a perspective view of the anastomosis device of FIG. 9 secured to the target vessel with the graft vessel omitted for clarity;

FIG. 12 is a perspective view of a further alternative embodiment of an anastomosis device prior to use;

FIG. 13 is a perspective view of an anastomosis device of FIG. 12 in a closed position in which the device would be used to connect a graft vessel to a target vessel;

FIG. 14 is a perspective view of an additional embodiment of an anastomosis device with an expandable linkage for deployment shown prior to use; and

FIG. 15 is a perspective view of the anastomosis device of FIG. 14 in an expanded position in which the device is used to connect a graft vessel to a target vessel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to an anastomosis device and method for connecting a graft vessel to a target vessel without the use of conventional sutures. The device according to the present invention greatly increases the speed with which anastomosis can be performed over prior art suturing methods. In addition, the anastomosis device provides a smooth transition between the graft vessel and the target vessel. The devices according to the present invention are particularly

designed for use in connecting graft vessels to small target vessels having relatively small diameters such as the coronary arteries. Suture of these small vessels is difficult with conventional techniques, particularly in minimally invasive procedures where space may be limited. The devices may also be used for connecting graft vessels to larger target vessels.

FIG. 1 illustrates an anastomosis device 10 according to a first embodiment of the present invention. The anastomosis device 10 includes a frame 12 and a plurality of fingers 14 extending from the frame. In use, an end of a graft vessel is inserted through the center of the device and everted around the frame 12. The fingers 14 are used as spreading members which are inserted into an opening in the target vessel and pulled away from one another to stretch and capture the edges of the opening in the target vessel.

FIG. 2 illustrates a blank 20 from which the anastomosis device 10 of FIG. 1 is formed. The blank includes the frame 12 having two parallel side beams 22 and two parallel end beams 24. The fingers 14 extend from the side beams 22. Preferably, the fingers 14 extending from one of the side beams 22 are staggered from the fingers extending from the other side beam as illustrated in FIG. 2. The preferred staggered arrangement of the fingers allows the device to be bent so that the fingers 14 extending from one of the side beams 22 extend into a gap between the fingers extending from the opposite side beam. As shown in FIG. 1, the free ends of each of the fingers 14 are bent into a J-shaped hook 26 which is used to grasp and spread the edges of an opening formed in a target vessel. The end beams 24 of the anastomosis device 10 are bent into a W-shape having a first bend 28 and a second bend 30. The first and second bends 28, 30 function as pivots or living hinges which allow the fingers 14 extending from the first side beam 22 to spread away from the fingers extending from the second side beam.

FIG. 3 illustrates the anastomosis device 10 with an end of a graft vessel 34 everted about the frame 12. Six slots 36 are formed in the graft vessel 34 so that

the fingers 14 can extend through the graft vessel when the vessel is everted around the frame 12. As shown in FIG. 3, an end 38 of the graft vessel 34 extends underneath and around the side beams 22 and the end beams 24 of the frame 12. The J-shaped hooks 26 of the fingers 14 are arranged substantially in a plane and inserted into an opening 40 or incision in the wall of a target vessel 42. The opening 40 is preferably formed longitudinally along the target vessel 42.

FIG. 4 illustrates the completed connection between the graft vessel 34 and the target vessel 42 with the anastomosis device 10. In particular, the device 10 of FIG. 3 has been bent so that the side beams 22 are pivoted outward and the angles of the first bend 28 and the second bend 30 are substantially straightened. As the bends 28, 30 in the frame 12 are straightened, the J-shaped hooks 26 of the fingers 14 move away from one another and out of the original insertion plane to stretch and capture the edges of the opening 40 in the target vessel 42. As illustrated in FIG. 4, the anastomosis device 10 presses the edges of the graft vessel 34 against an exterior surface of the target vessel 42 around the opening 40 in the side of the target vessel.

Although the embodiment of FIGS. 1 - 4 has been illustrated with three fingers 14 extending from each of the side beams 22, it should be understood that other numbers of fingers may also be used without departing from the present invention. As illustrated in FIG. 4, only a small amount of metal of the anastomosis device comes in contact with the blood. In particular, the fingers 14 extending through the slots 36 in the side walls of the graft vessel 32 come into contact with the blood while the remainder of the anastomosis device is outside of the blood flow area.

Preferably, the finger linkage anastomosis device of FIGS. 1 - 4 is cut from a metal tube such as a steel tube and is then formed into the shape illustrated in FIG. 1 by bending. The fingers 14 are interlaced and the free ends of the fingers are bent downwards into the J-shaped hooks 26. The graft vessel 34 is initially

pulled between the fingers and pierced by the fingers to form the slots 36. The end of the graft vessel 34 is wrapped around the frame 12. To attach the graft vessel 34 to the target vessel 42, the J-shaped hooks 26 are inserted into the incision 40 in the target vessel. When the side beams 22 are rotated outwards, the J-shaped hooks 26 open the incision 40 in the target vessel 42 and secure the graft vessel 34 to the target vessel. Rotation of the side beams 22 of the frame 12 causes plastic deformation of the anastomosis device primarily at the first and second bends 28, 30 and seals the graft vessel 34 against the exterior of target vessel 42.

FIG. 5 illustrates an alternative embodiment of an anastomosis device 50 having a single scissor configuration. The anastomosis device 50 according to FIG. 5 includes an inner loop 52 connected to an outer loop 54 by two hinges 56.

FIG. 6 illustrates a flat plan view of a blank 60 for forming the anastomosis device 50. The blank 60 includes the inner loop 52 and the outer loop 54 connected by the two hinges 56. The inner loop 52 has two teeth 62 extending from opposite ends of the inner loop. In addition, the outer loop 54 has two teeth 64 extending from each end of the outer loop. As illustrated in FIG. 5, the teeth 62, 64 are bent to grasp and hold the graft and target vessels together. The anastomosis device 50 of FIG. 5 is preferably cut from a tube and bent into the shape illustrated in FIG. 5. The inner loop 52 is connected to the outer loop 54 at the hinges 56 which are positioned along a bending axis X of the device. Prior to use, the blank 60 including the inner and outer loops 52, 54 is bent in a C-shape and the inner and outer loops are pivoted so that the C-shapes face opposite directions.

As illustrated in FIG. 7, the graft vessel 66 is inserted between the inner and outer loops 52, 54 and everted over the upper ends of the inner and outer loops such that ends of the graft vessel 66 become caught on the teeth 62, 64. The lower end of the device is arranged substantially in a plane and is inserted through

an opening 70 in the target vessel 72 with the teeth 62, 64 on the lower end of the device pointing outward. The upper ends of the inner and outer loops 52, 54 are then pivoted away from one another to seat the device into the inner wall of the target vessel and secure the graft vessel 66 to the target vessel 72 as illustrated in FIG. 8. The pivoting action of the anastomosis device of FIG. 5 is similar to the pivoting action of scissors being opened and moves the lower ends of the inner and outer loops 52, 54 out of the insertion plane. As illustrated in FIG. 8, once the graft vessel 66 and target vessel 72 have been connected with the anastomosis device 50, the edges of the everted graft vessel and the side walls of the target vessel 72 around the opening 70 are both grasped between the inner and outer loops 52, 54 of the frame on either side of the opening 70.

FIG. 9 illustrates an alternative embodiment of an anastomosis device 80 having two pivoting members or a double scissor arrangement. The anastomosis device 80 includes a frame 82 and first and second pivoting U-shaped members 84, 86. The frame 82 includes side beams 88 having barbs 90 extending downward from an exterior edge of the side beams. The side beams are connected by end beams 92. Extending from the side beams 92 are four locking tabs 94. The first and second pivoting U-shaped members 84, 86 are connected on either end to a central portion of the end beams 92 by pivot joints 96. Two lever arms 98 extend from each of the U-shaped members 84, 86 adjacent the pivot joints 96.

In use, an end of a graft vessel (not shown) is inserted into the center of the frame above the U-shaped members 84, 86 and wrapped around or everted over the barbs 90 on the side beams 88. The U-shaped members 84, 86 are arranged in a substantially parallel configuration as shown in FIG. 9 and are substantially in a plane for insertion into a slit shaped opening 100. The U-shaped members 84, 86 are inserted through the opening 100 or incision in the target vessel 102. The two lever arms 98 are then each rotated in the direction of the corresponding arrows A in FIG. 9 to pivot the U-shaped members 84, 86 at the pivot joints 96 moving the

U-shaped members out of the insertion plane. The opened U-shaped members 84, 86 clamp the side wall of the target vessel 102 between the U-shaped members and the side beams 88 of the frame 82. The lever arms 98 are then folded down and locked in place by folding up the four locking tabs 94 and sliding the lever arms into slots 104 in the tabs.

The graft vessel has been omitted from FIGS. 9 and 10 for purposes of clarity. However, it should be understood that the end of the graft vessel as well as the edges of the opening 100 in the target vessel 102 are captured between the frame 82 and the U-shaped pivoting members 84, 86. The square holes 106 in the ends of the frame 82 may be used by an inserting device to grasp the anastomosis device 80. The edges of the pivoting U-shaped members 84, 86 may include serrated edges for incising a target vessel to form the opening 100 in the target vessel.

FIG. 12 and 13 show a variation of the double scissor arrangement for an anastomosis device of FIG. 9. The anastomosis device 110 of FIG. 12 includes a frame 112, and first and second pivoting U-shaped members 114, 116. The U-shaped members 114, 116 are joined to the frame 112 by pivots or living hinges 118. The pivots 118 are offset vertically from the frame 112 by offset arms 120. The offset arms 120 preferably have a length which is substantially equal to a thickness of the target vessel wall. Two lever arms 122 extend from each of the first and second U-shaped members 114, 116. The lever arms 22 are rotated in the direction of the arrows A to pivot the U-shaped members 114, 116 about the pivots 118 and trap the side walls of the target vessel between the U-shaped members and the frame 112. The lever arms 122 may be provided with rectangular openings 130 which are used by an associated deployment device to manipulate the lever arms.

According to the embodiment of FIGS. 12 and 13, the frame 112 is provided with a plurality of points 124 on an exterior surface of the frame which

hold the everted graft vessel to the frame. Once the graft vessel is punctured by the points 124, the graft vessel cannot slip off the points. The frame 112 includes locking tabs 126 at either end having recesses 128 for receiving the lever arms 122 in a locked positioned as illustrated in FIG. 13.

FIGS. 14 and 15 illustrate an alternative embodiment of an anastomosis device 140 which is longitudinally expandable to cause a lower portion of the device to fold outward trapping the walls of the target vessel with the device. The anastomosis device 140 includes a plurality of linkages 142 which are arranged in two substantially parallel rows. Each of the linkages 142 includes four angled struts 144 which form a substantially diamond shape in the configuration of FIG. 14 and vertical bendable struts 146 positioned vertically in the center of each of the diamonds formed by the angled struts. Each of the linkages 142 also includes a lower prong 148 arranged substantially vertically for insertion into an opening in the target vessel and an upper prong 150 which is oriented substantially perpendicular to the lower prong in the insertion configuration of FIG. 14. The upper and/or lower prongs 148, 150 may include barbs 152. Some of the upper prongs 150 may include loops 154 or other grasping members which can be used by a deployment tool to grasp the anastomosis device 140 during insertion and deployment. Finally, each of the linkages 142 includes one or more stabilizing struts 156. The stabilizing struts 156 may have a curved configuration to allow longitudinal expansion of the anastomosis device 140.

The anastomosis device 140 includes end members 158, 160 which connect the ends of the two rows of linkages 142. The end members 158, 160 may take on many different configurations. In the example of the anastomosis device 140 illustrated in FIGS. 14 and 15, the device is formed from a continuous sheet of material. Therefore, the end member 158 is folded to align the first and second rows with one another while the second end member 160 includes a lock member 162 which holds the ends of the rows of linkages together. Each of the end

members includes one or more loops 164 or grasping members which are grasped by a deployment tool. The end members 158, 160 also preferably include prongs 166 to help grasp the tissue of the everted graft vessel.

In use, a graft vessel (not shown) is inserted through a center of the anastomosis device 140 and an end of the graft vessel is everted over the lower prongs 148 of the device. The graft vessel may also be everted over the upper prongs 150 and the end member prongs 166. The prongs 148, 150, 166 pierce through the graft vessel to securely hold the graft vessel in place in the anastomosis device 140. Once the graft vessel has been loaded onto the anastomosis device 140, the lower prongs 148 of the device which are positioned substantially in a plane and the everted end of the graft vessel are inserted through a slit shaped opening in the target vessel. The loops 164 on the end members 158, 160 are then used to expand the device in a longitudinal direction with a deployment tool or manually. The longitudinal expansion of the device of FIG. 14 causes each of the diamond shaped linkages 142 of angled struts 144 to expand longitudinally and causes the bendable vertical struts 146 to bend at their hinges 170.

The expanded configuration of the anastomosis device 140 is illustrated in FIG. 15. The anastomosis device deployment tool may also expand the device in a direction transverse to the longitudinal axis of the device 140 to enlarge the opening of the target vessel for increased blood flow. Once deployment of the anastomosis device 140 is complete, the wall of the target vessel around the opening in the target vessel is trapped between the upper and lower prongs 148, 150. In the expanded configuration shown in FIG. 15, the upper and lower prongs 148, 150 are preferably substantially parallel. Alternatively, an angle may be formed between the upper and lower rows of prongs 148, 150.

The anastomosis device 140 of FIGS. 14 and 15 may also be formed as a two piece device or may be split in half at the ends after deployment. The

compliance of a split or two piece anastomosis device will allow the device and graft site to flex in response to blood flow.

Each of the anastomosis devices described above are preferably single piece devices which are formed by laser cutting or punching from a tube or sheet of material. The devices may be provided in varying sizes to join vessels of different sizes. The teeth, barbs, or points which have been discussed above with regard to the various embodiments may be used in varying numbers and arrangements to help secure the vessels in place.

Although the invention has been principally discussed with respect to coronary bypass surgery, the anastomosis devices of the present invention may be used in other types of anastomosis procedures. For example, the anastomosis device may be used in femoral-femoral bypass, vascular shunts, subclavian-carotid bypass, organ transplants, and the like. The anastomosis device may be used with natural or synthetic graft vessels.

The anastomosis devices may be made of any known material which can be bent and will retain the bent shape such as stainless steel, nickel titanium alloys, and the like. The hinges or pivot joints which have been discussed above in the various embodiments of the present invention may be designed to concentrate the bending at a desired location. For example, the pivot joints 96 of the anastomosis device 80 of FIGS. 9 and 10 may be formed with a thickness or width which is smaller than other portions of the frame and the U-shaped members in order to concentrate the bending in the pivot joints.

While the invention has been described in detail with reference to the preferred embodiments thereof, it will be apparent to one skilled in the art that various changes and modifications can be made and equivalents employed, without departing from the present invention.

WHAT IS CLAIMED IS:

1. An anastomosis device for connecting a graft vessel to a target vessel, the device comprising:

at least two spreading members being substantially in a plane in an undeployed state, the spreading members moving out of the plane to support an opening in a target vessel in a deployed state.

2. The anastomosis device of Claim 1, wherein the spreading members each include a plurality of fingers with J-shaped free ends for grasping the edges of the opening in the target vessel.

3. The anastomosis device of Claim 2, wherein the plurality of fingers of a first of the spreading members are staggered with respect to the plurality of fingers of a second of the spreading members.

4. The anastomosis device of Claim 1, wherein the spreading members move out of the plane by pivoting with respect to a frame.

5. The anastomosis device of Claim 1, wherein the spreading members are U-shaped members which are connected to each other by at least one pivot connection.

6. The anastomosis device of Claim 1, wherein the spreading members are U-shaped spreading members connected on each end to a frame by a pivot connection.

7. The anastomosis device of Claim 6, further comprising at least one lever arm extending from each of the U-shaped spreading members for moving the U-shaped spreading members apart.

8. The anastomosis device of Claim 5, further comprising a locking device for locking the U-shaped spreading members in an open position in which the edges of the opening in the target vessel and the graft vessel are captured between the U-shaped spreading members and a frame.

9. The anastomosis device of Claim 1, further comprising a frame having at least one opening for holding the device with a deployment device and the spreading members include features for moving the spreading members with the deployment device.

10. The anastomosis device of Claim 1, wherein the spreading members each include a plurality of linkages, wherein expansion of the linkages cause the spreading members to move out of the plane.

11. The anastomosis device of Claim 10, wherein the linkages each include a plurality of angled struts surrounding a bendable central strut and expansion of the linkages cause the bendable struts to bend.

12. The anastomosis device of Claim 1, wherein the spreading members include teeth for grasping tissue.

7. The anastomosis device of Claim 6, further comprising at least one lever arm extending from each of the U-shaped spreading members for moving the U-shaped spreading members apart.

8. The anastomosis device of Claim 5, further comprising a locking device for locking the U-shaped spreading members in an open position in which the edges of the opening in the target vessel and the graft vessel are captured between the U-shaped spreading members and a frame.

9. The anastomosis device of Claim 1, further comprising a frame having at least one opening for holding the device with a deployment device and the spreading members include features for moving the spreading members with the deployment device.

10. The anastomosis device of Claim 1, wherein the spreading members each include a plurality of linkages, wherein expansion of the linkages cause the spreading members to move out of the plane.

11. The anastomosis device of Claim 10, wherein the linkages each include a plurality of angled struts surrounding a bendable central strut and expansion of the linkages cause the bendable struts to bend.

12. The anastomosis device of Claim 1, wherein the spreading members include teeth for grasping tissue.

13. An anastomosis device for connecting a graft vessel to a target vessel, the device comprising:

a frame for receiving and holding a graft vessel; and

first and second spreading members configured to be inserted into a target vessel, at least one of the spreading members movably connected to the frame, allowing movement of the spreading members with respect to each other;

wherein the frame is deformable and deformation of the frame moves the spreading members.

14. The anastomosis device of Claim 13, wherein the frame and the spreading members form a scissor shape.

15. The anastomosis device of Claim 13, wherein the frame and spreading members from a substantially W-shape and the spreading members include hook shaped ends.

16. The anastomosis device of Claim 13, wherein the frame includes a plurality of expandable linkages arranged in two substantially parallel rows.

17. An anastomosis device for connecting a graft vessel to a target vessel, the device comprising:

a frame for receiving and holding a graft vessel;

first and second spreading members configured to be inserted into a target vessel, at least one of the spreading members movably connected to the frame, allowing movement of the spreading members with respect to each other; and

features provided on the spreading members for moving the spreading members with respect to the frame.

18. The anastomosis device of Claim 17, wherein the features are lever arms.

19. The anastomosis device of Claim 18, further comprising locking tabs.

20. An anastomosis device for connecting a graft vessel to a target vessel, the device comprising:

a frame for receiving and holding a graft vessel; and

first and second spreading members configured to be inserted into a target vessel, at least one of the spreading members movably connected to the frame, allowing movement of the spreading members with respect to each other;

wherein the frame includes features for deforming the frame to move the spreading members.

21. The anastomosis device of Claim 20, wherein the frame is deformable by expanding linkages in the spreading members which cause the spreading members to fold.

22. An anastomosis device for connecting a graft vessel to a target vessel, the device comprising:

a plurality of linkages arranged in two rows for grasping opposite sides of an opening in the target vessel, each of the plurality of linkages including a plurality of angled struts surrounding a bendable central strut; and

two end members connected to opposite ends of the two rows which when moved away from one another expand the linkages and cause the bendable central struts to bend, folding a portion of the linkages outward to trap vessel walls on opposite sides of the opening in the target vessel.

23. The anastomosis device of Claim 22, wherein the linkages are diamond linkages connected to each other at side corners.

24. The anastomosis device of Claim 23, wherein the bendable central struts are connected between upper and lower portions of the diamond linkages.

25. The anastomosis device on Claim 24, wherein the bendable central struts each include a reduced cross section hinge.

26. The anastomosis device of Claim 22, wherein the end members include grasping portions for grasping the end members and pulling them away from each other.

27. A method of performing anastomosis comprising:

providing a one-piece anastomosis device;

everting a graft vessel around a first portion of the anastomosis device;

inserting a second portion of the anastomosis device into an opening in a side wall of a target vessel, the second portion having a substantially planar configuration in a undeployed state; and

spreading the second portion to capture edges of the opening in the target vessel with the anastomosis device such that a fluid passage is established between the graft and the target vessel.

28. The method of Claim 27, wherein the target vessel is a coronary artery.

29. The method of Claim 27, wherein of the graft vessel and the edges of the opening in the target vessel are captured between the first portion and the second portion and the graft vessel abuts an outside of the target vessel.

30. The method of Claim 27, wherein the anastomosis device is used to incise the target vessel to form the opening in the side wall of the target vessel.

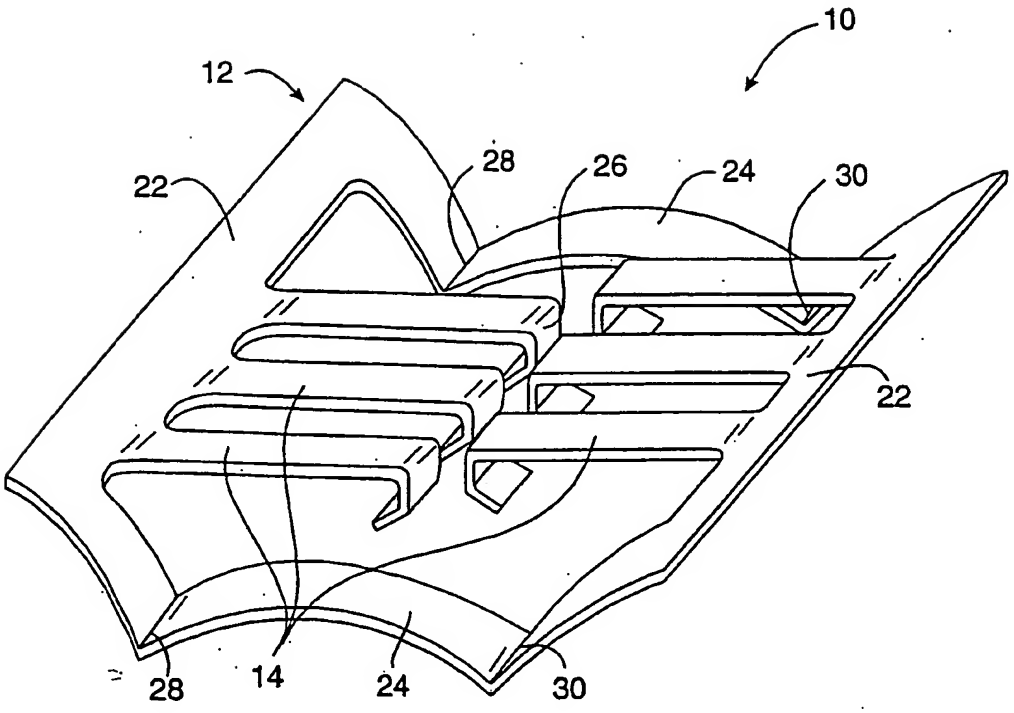

FIG. 1

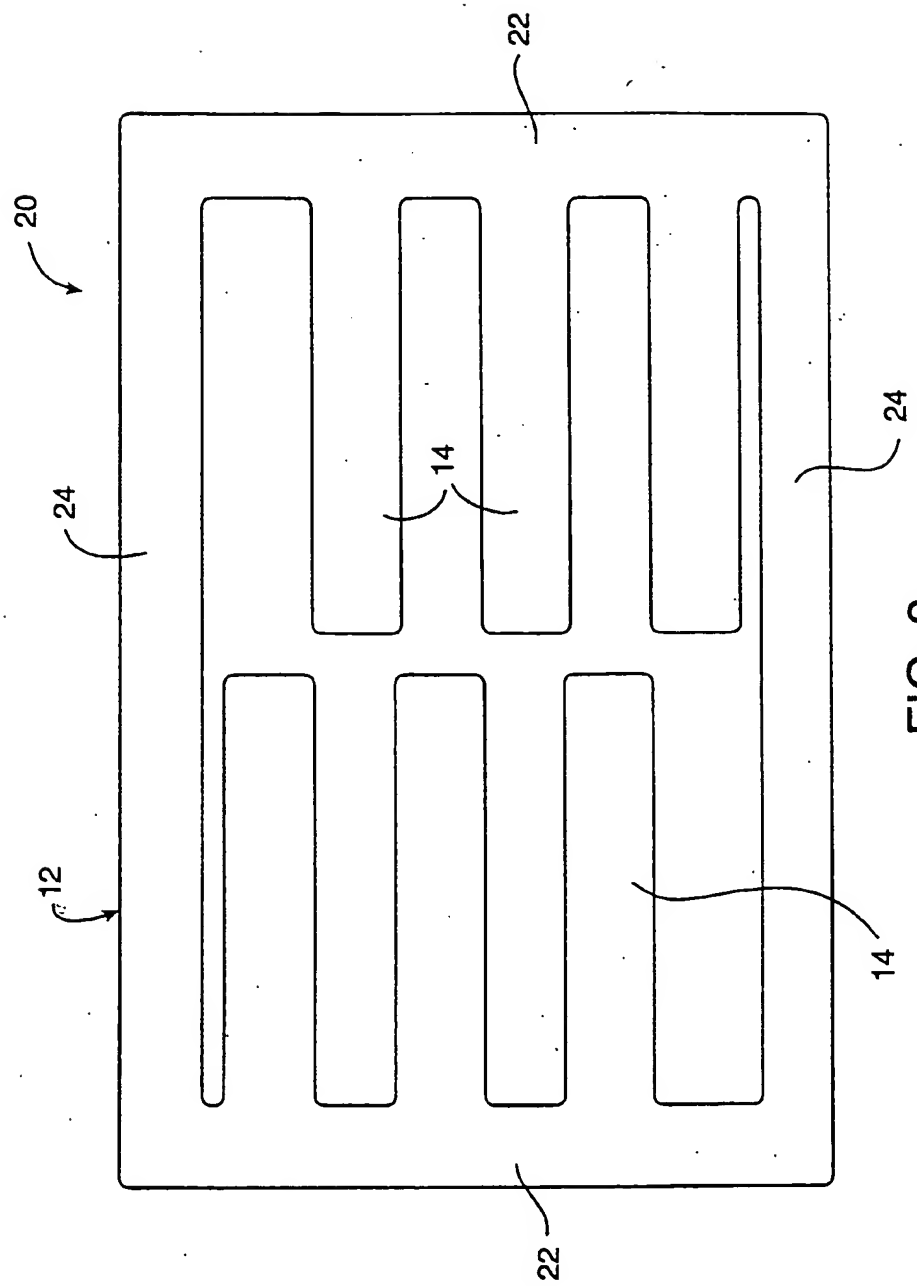

FIG. 2

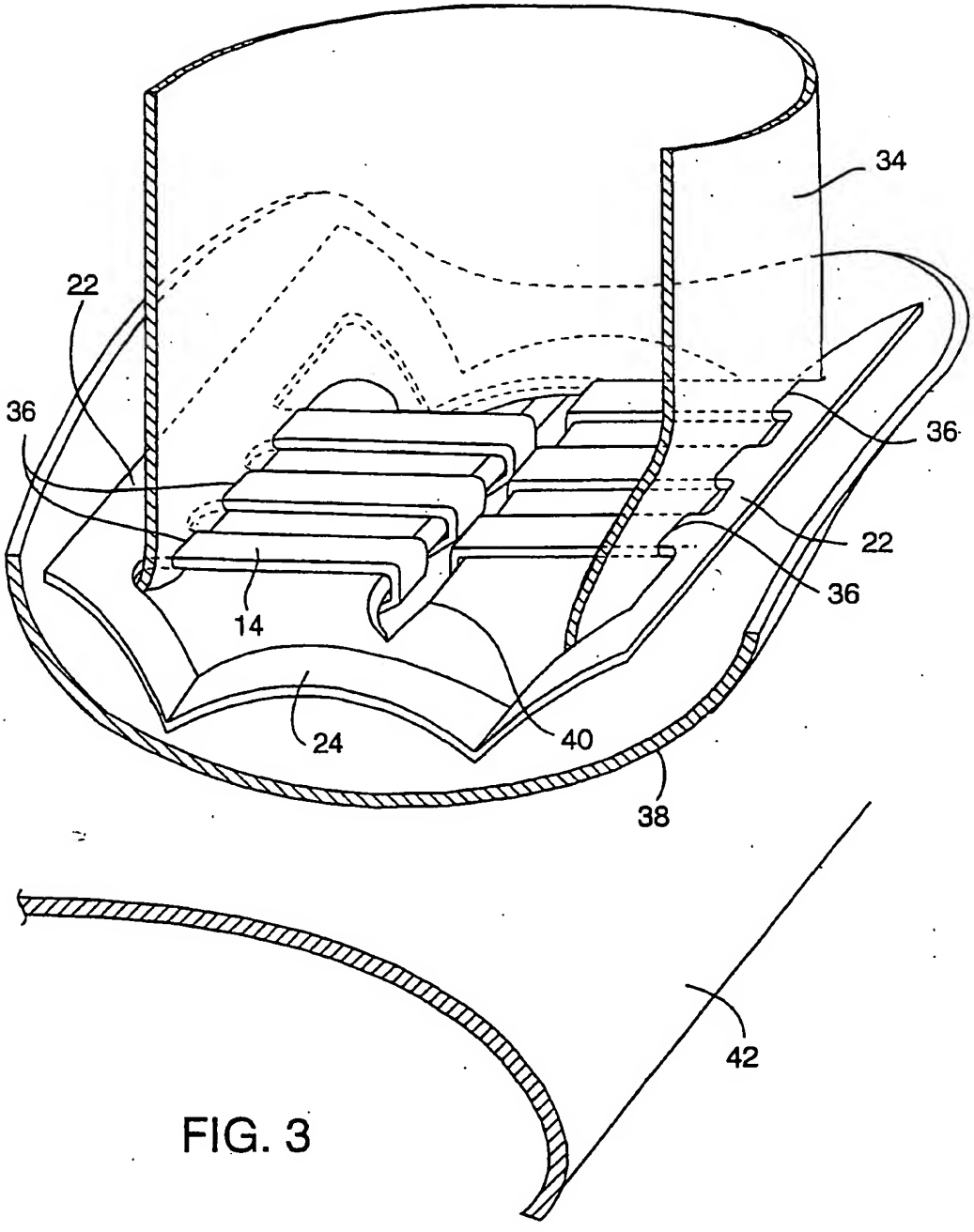

FIG. 3

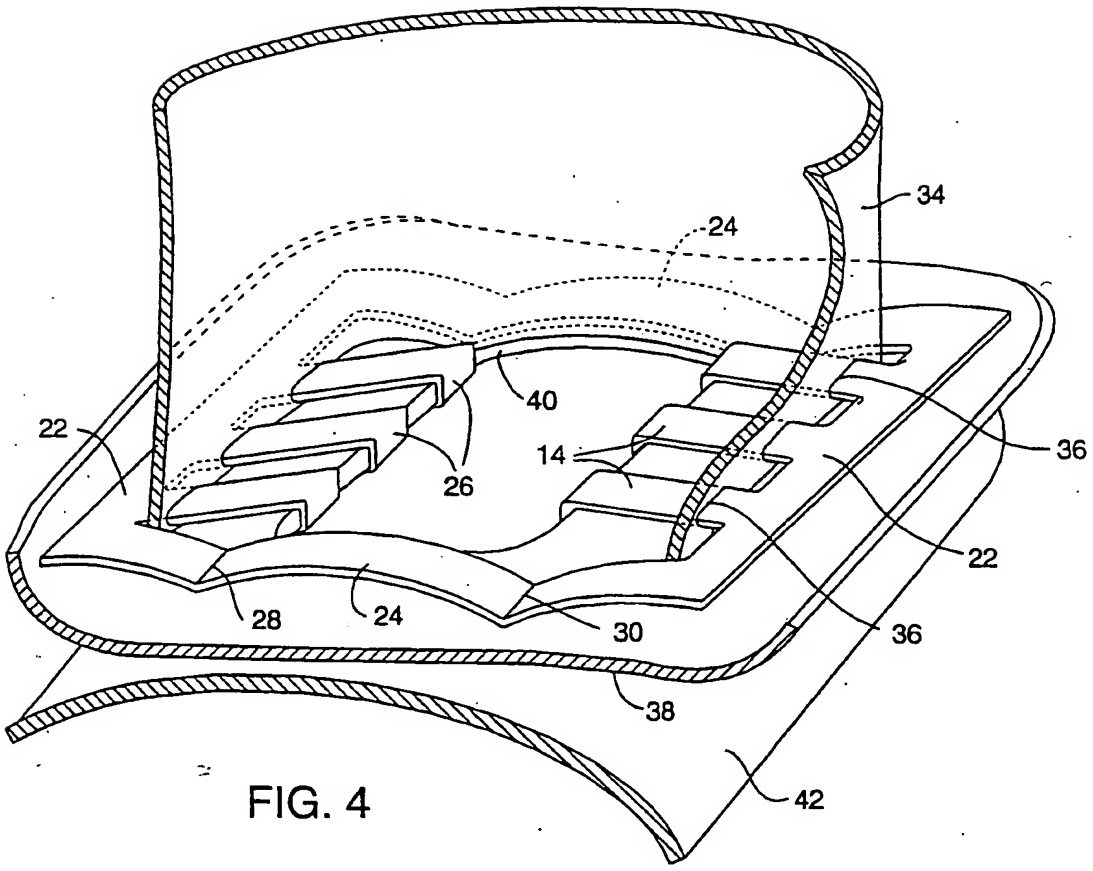

FIG. 4

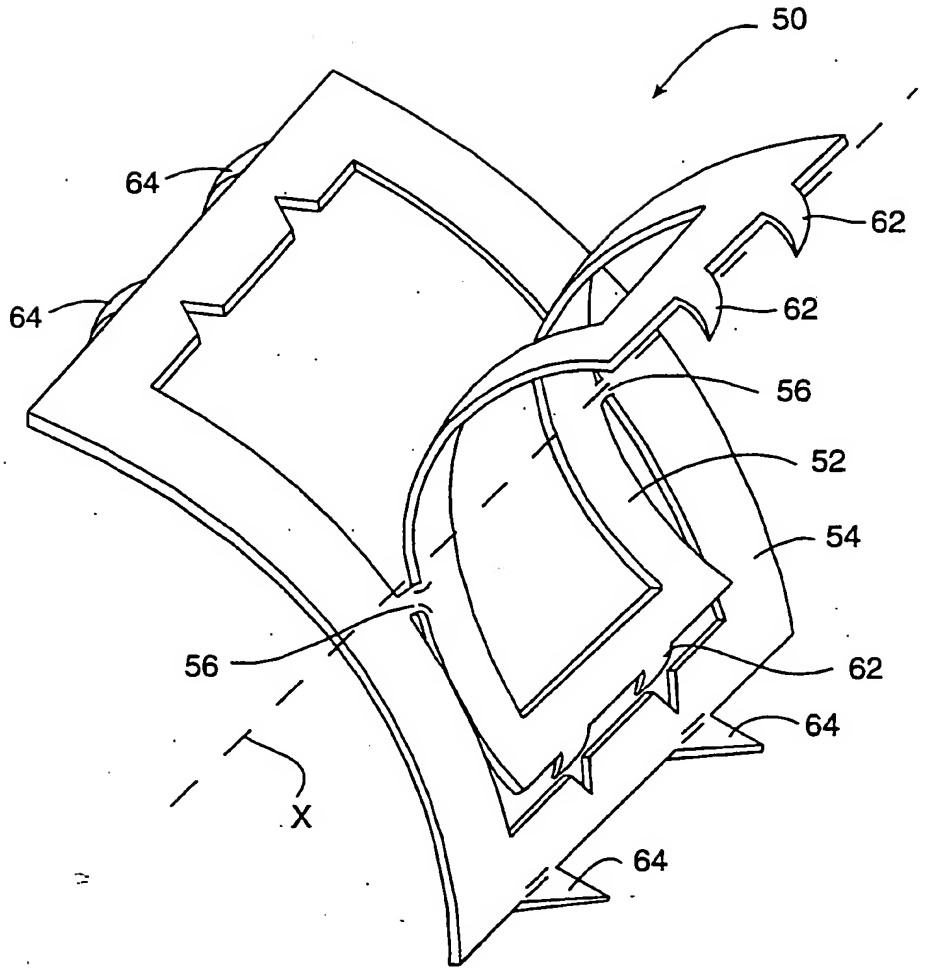

FIG. 5

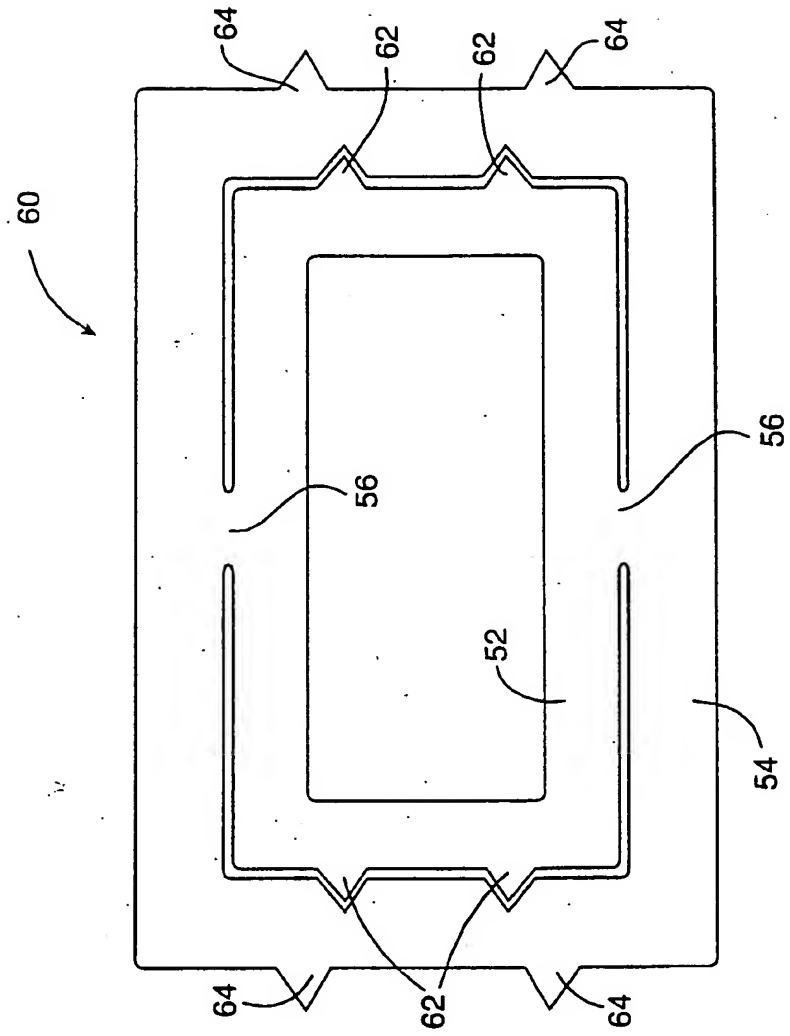

FIG. 6

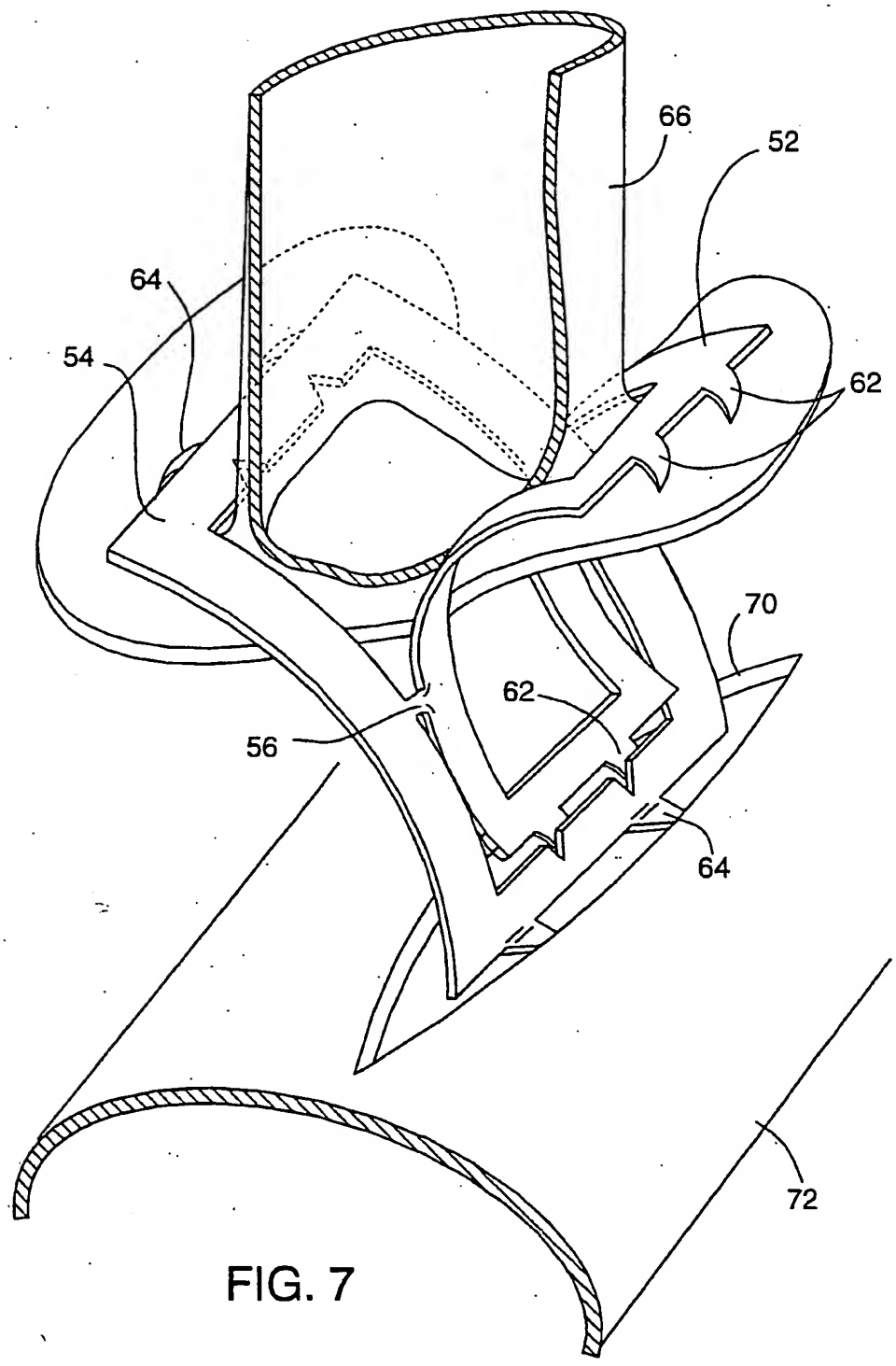

FIG. 7

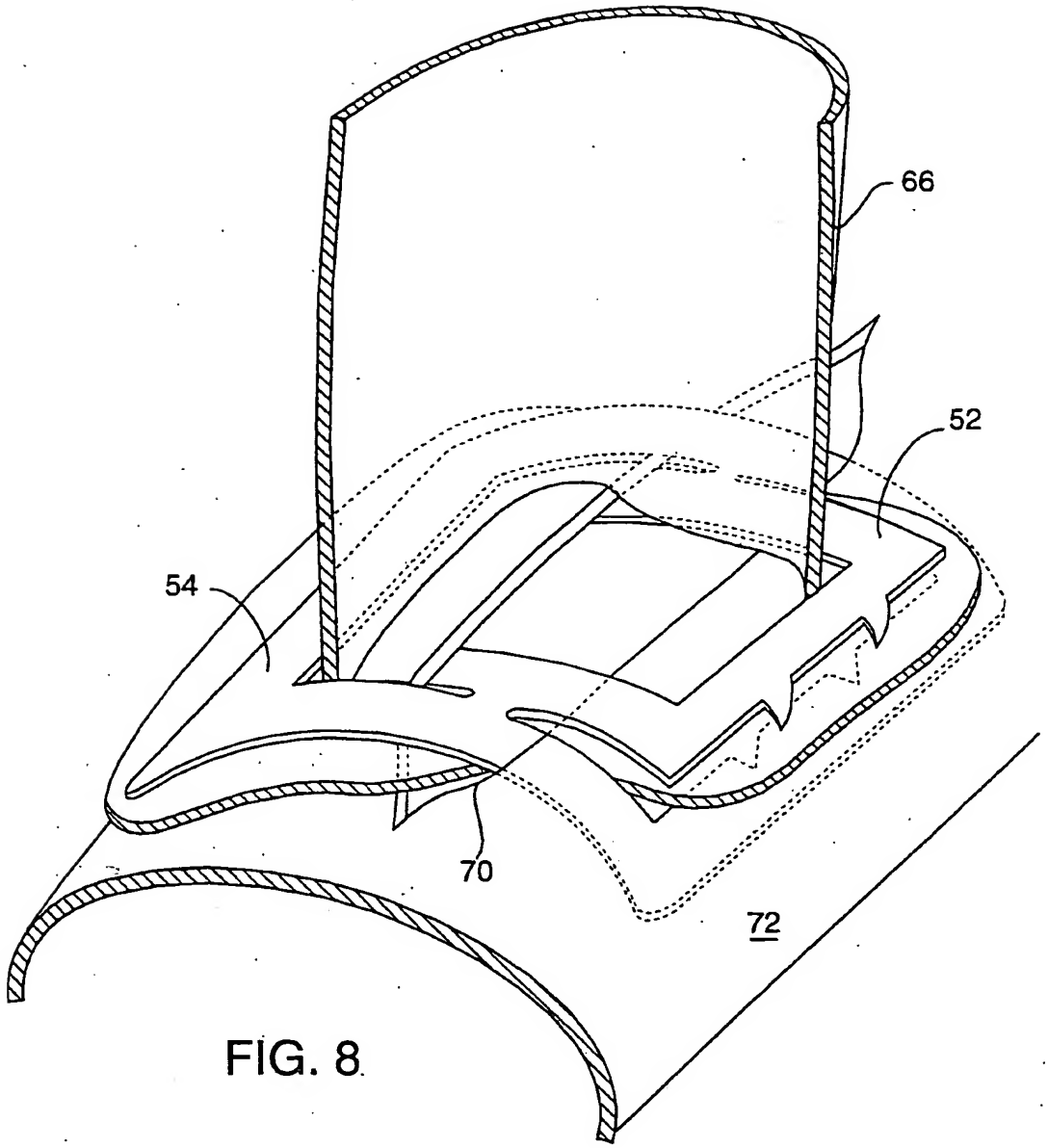

FIG. 8

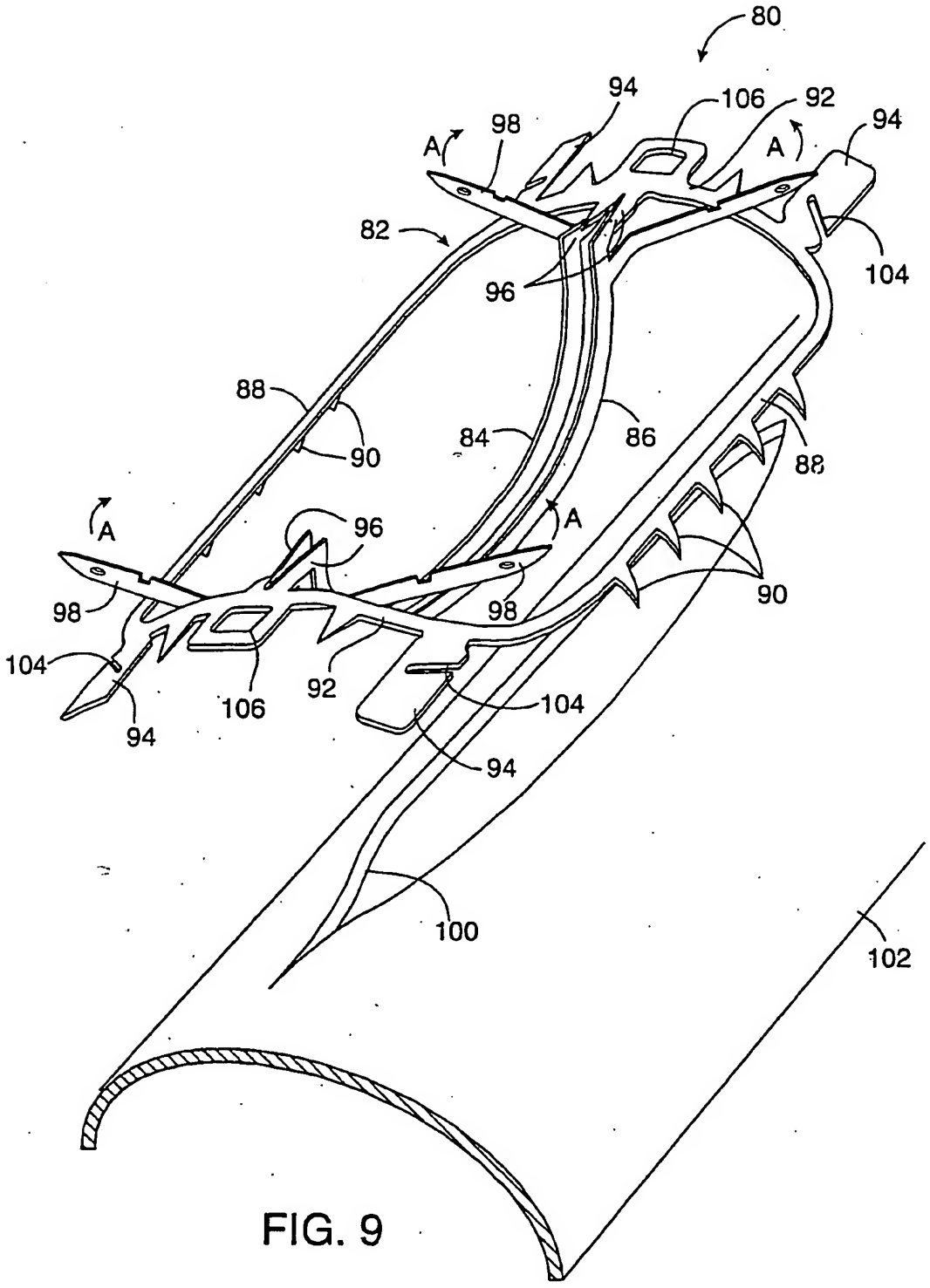
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FIG. 9

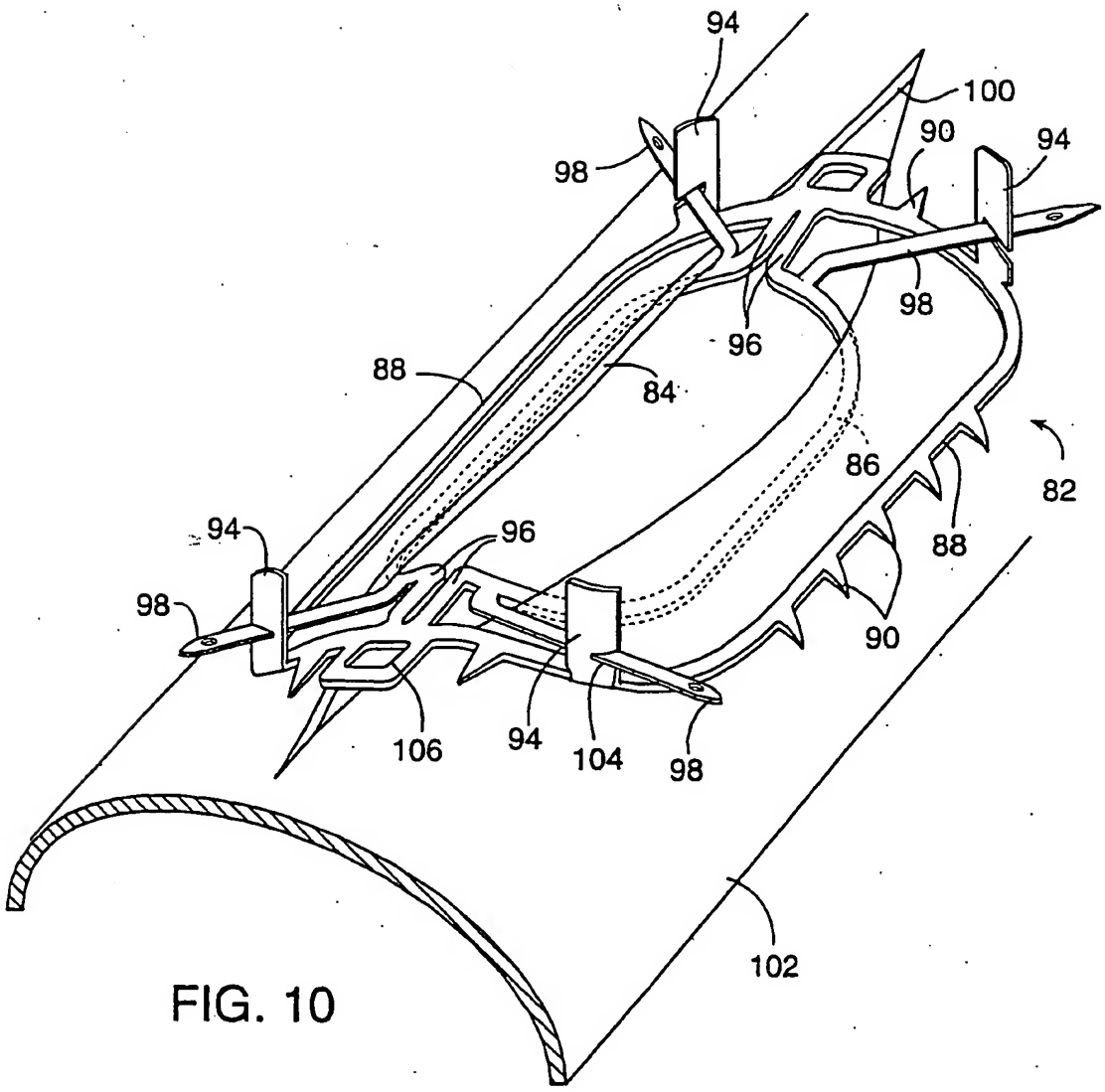

FIG. 10

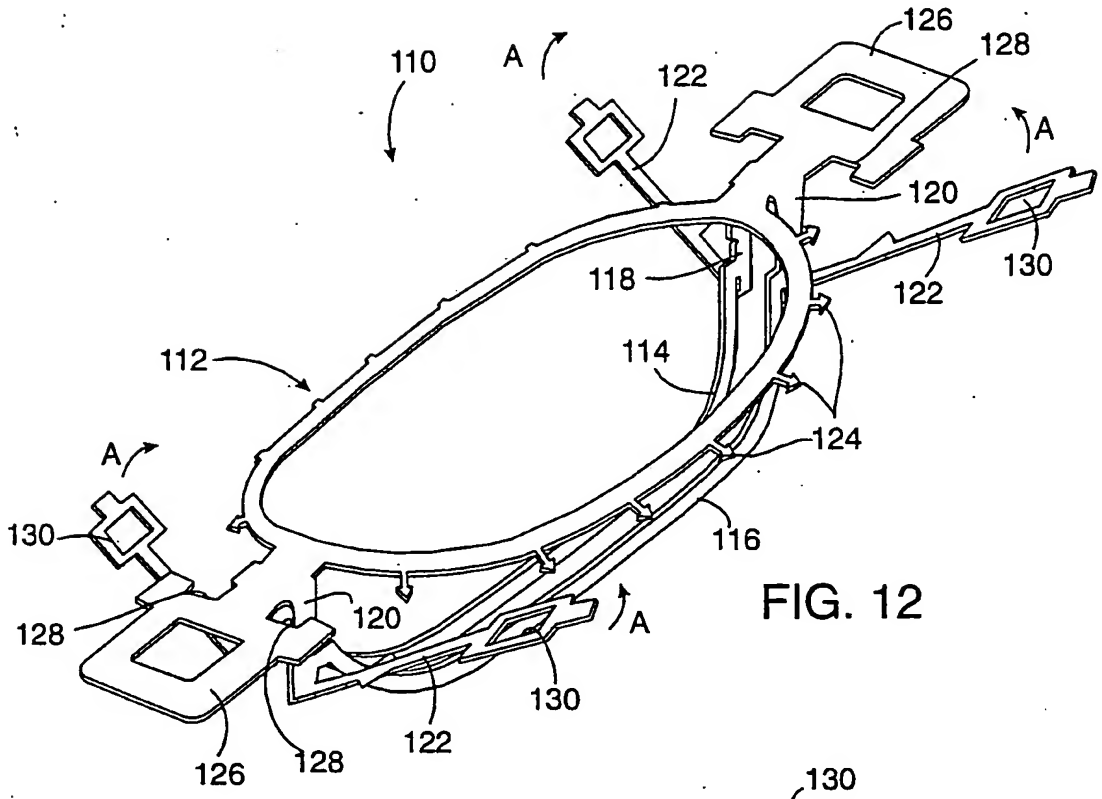
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FIG. 12

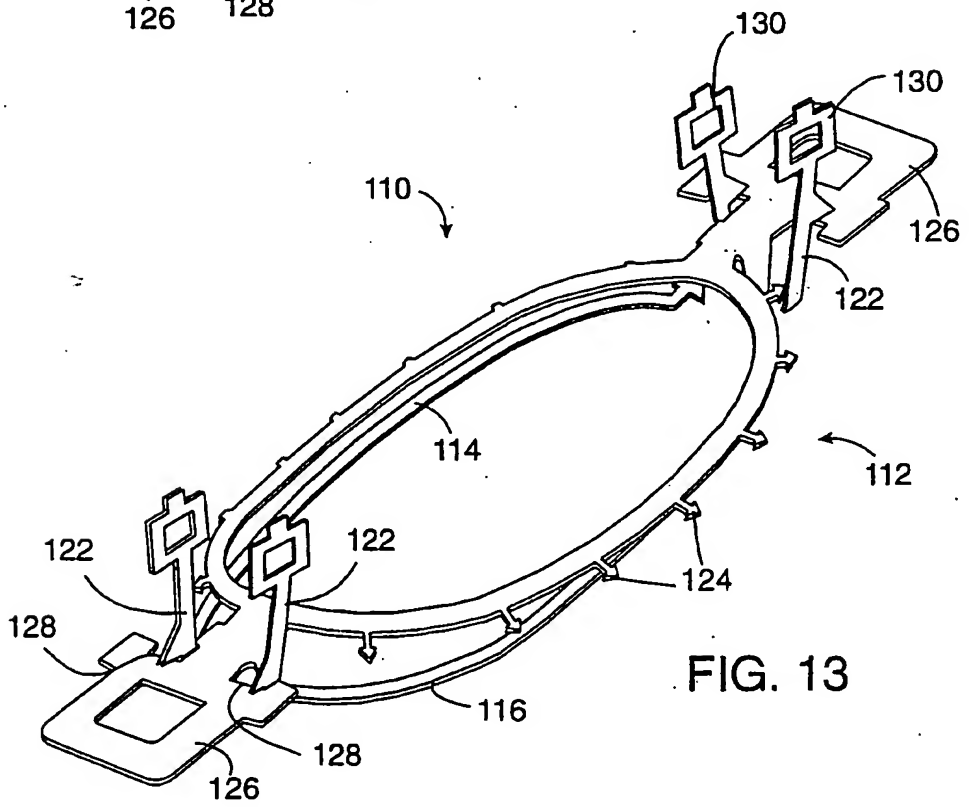
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FIG. 13

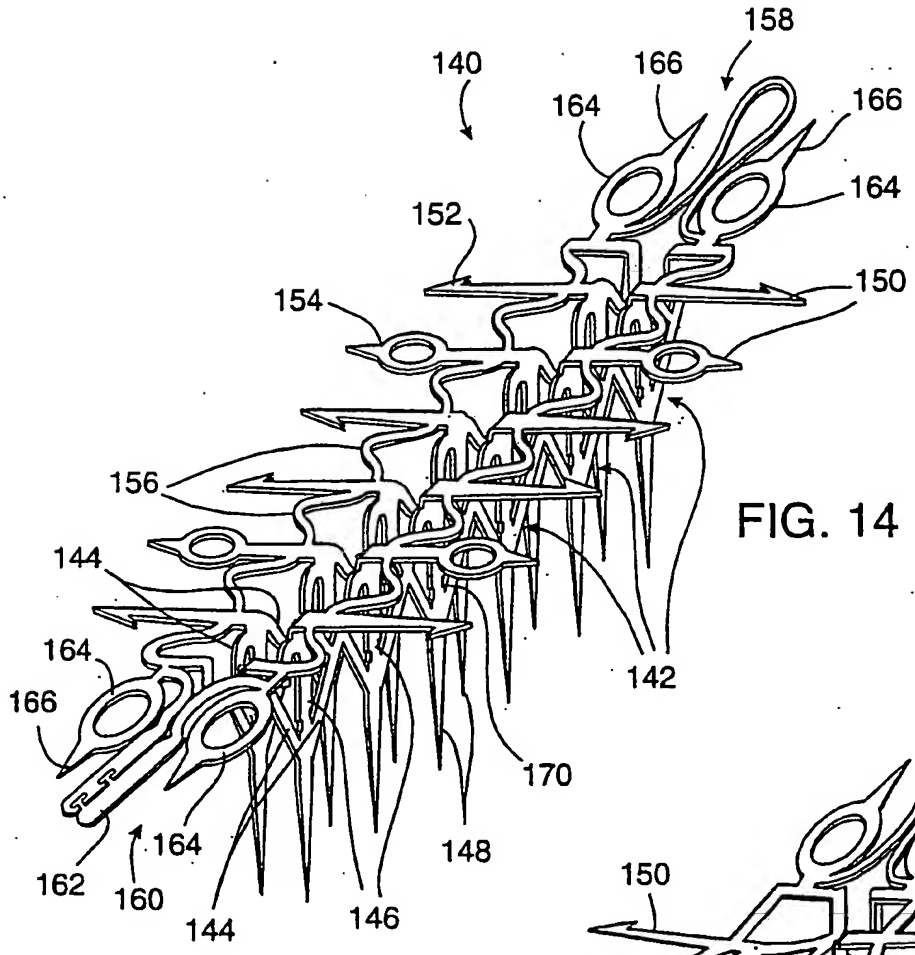
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FIG. 14

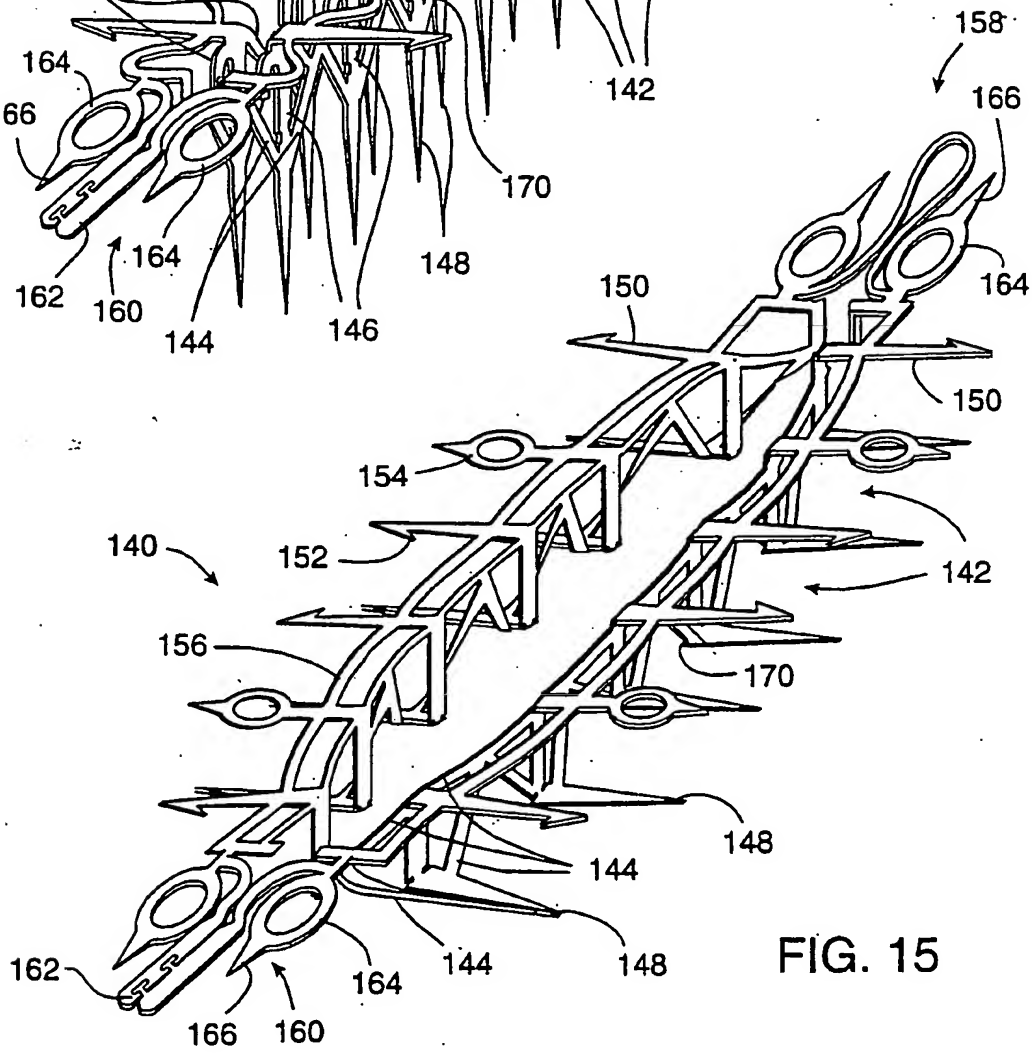
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FIG. 15

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 00/14034

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B17/11

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 868 763 A (CHRISTAKIS GEORGE ET AL) 9 February 1999 (1999-02-09) column 12, line 58 -column 15, line 44A; figures 11A-221,13,17,20,22	1,13,17, 20,22
P,A	WO 99 39643 A (KRAIMER WILLIAM J ;EVANS DAVID K (US); KATZ HAL H (US); BRINKERHOF) 12 August 1999 (1999-08-12) the whole document	1,2,9, 13,17, 20,22

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 September 2000	27/09/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ducreau, F

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte. onal Application No
PCT/US 00/14034

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5868763 A	09-02-1999	NONE	
WO 9939643 A	12-08-1999	AU 2587599 A	23-08-1999